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Document Name: SAE J334: Protective Frame Test Procedures and Performance Requirements

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PROTECTIVE FRAME PERFORMANCE REQUIREMENTS — SAE J334

SAE Recommended Practice

Report of Tractor Technical Committee approved April 1968.

1. Purpose—The purpose of this recommended practice is to establish requirements of a frame for the protection of operators on agricultural and light industrial tractors to minimize the possibility of operator injury resulting from accidental upsets during normal operation.

2. Scope

2.1 This recommended practice establishes the test procedures and minimum performance necessary to fulfill the intended purpose.

2.2 Fulfillment of the intended purpose requires two separate test procedures as follows:

2.2.1 A laboratory test, either static or dynamic, under repetitive and controlled loading, to permit analysis of the protective frame to insure compliance with the purpose of the standard.

2.2.2 A field upset under reasonably controlled conditions, both rearward and sideways, to verify effectiveness of the protective frame under actual dynamic conditions.

2.3 The test procedures and minimum performance requirements outlined in this recommended practice are based on currently available engineering data.

3. Definitions

3.1 An agricultural tractor is a wheeled or track type vehicle designed to furnish the power to pull, carry, propel, or drive implements that are designed for agricultural use.

3.2 A light industrial tractor is that class of wheeled or track type tractor used in operations such as landscaping, construction services, loading, digging, grounds keeping, and highway maintenance.

3.3 Basic tractor weight includes the protective frame, all fuels, and other components required for normal use of the tractor. Not included in the basic weight are wheel weights, front or rear weights, tire ballast, tractor operator, mounted implements, mounted equipment, or any specialized components.

5.2.1.3 The test shall be conducted on a dry firm soil slope of between 2.25-2.50 units of horizontal distance per unit of rise. The slope shall be at least 35 ft (10.7 m) wide at 90 deg to the direction of vehicle travel to allow for the possibility of greater than 180 deg of vehicle roll. The slope shall be at least 100 ft (30.5 m) long to allow for the vehicle to be operated at proper travel speed at the instant of overturn.

5.2.1.4 The upper edge of the slope shall be fitted with a ramp as in Fig. 2 which shall be used for actually tipping the vehicle.

5.2.1.5 The front and rear wheel tread settings, where adjustable, shall be at the position nearest to halfway between the minimum and maximum settings obtainable on the vehicle.

5.2.2 Vehicle Overturn Tests—Sideways and Rearward

5.2.2.1 The tractor shall be driven under its own power along the embankment at a minimum speed of 10 mph (16.1 km/hr) or maximum vehicle speed if under 10 mph (16.1 km/hr) up the ramp as described in paragraph 5.2.1.4 until overturn sideways is induced at this speed.

5.2.2.2 Rear upset shall be induced by engine power with tractor operating in a gear to obtain 3-5 mph (4.8-8.0 km/hr) at maximum governed engine rpm, preferably by driving forward directly up a minimum slope of two vertical to one horizontal. The engine clutch may be used to aid in inducing the upset.

5.2.3 Vehicle Overturn Test Performance Requirements

5.2.3.1 The protective frame may be deformed as specified in paragraph 5.2.3.3 but shall not shatter or leave sharp edges exposed to the operator.

5.2.3.2 There shall be no visually noticeable fractures or cracks in any structural component.

5.2.3.3 Minimum allowable dimensions during tests as shown in Figs. 3 and 4 are:

D = 2 in. (51 mm) inside of frame upright to vertical center line of seat

E = 30 in. (762 mm). Dimensions relative to the seat are determined with the seat unloaded and adjusted to its highest and most rearward latched position provided for a seated operator

4. Description

4.1 **Protective Frame**—The protective frame to which this recommended practice applies is a structure generally comprising one or more uprights mounted to the tractor, extending above the operator's seat and conforming generally to Fig. 1.

4.2 **Overhead Weather Shield**—If an overhead weather shield is available for attachment to the protective frame, it may be in place during tests, providing it does not contribute to the strength of the protective frame. If used, it must comply with paragraph 5.5.3.

5. Test Procedure and Performance Requirements

5.1 General

5.1.1 The procedures are as specified in paragraphs 5.2, 5.3, and 5.4.

5.1.2 The tractor used shall be the tractor with the greatest basic weight on which the protective frame is to be used.

5.1.3 A new protective frame and mounting connections of the same design shall be used for each test.

5.1.4 Instantaneous and permanent frame deformation shall be measured and recorded for each segment of the test. Minimum dimensions during test are specified for each test.

5.2 Vehicle Overturn Test Procedure

5.2.1 Test Conditions

5.2.1.1 Agricultural tractor as defined in paragraph 3.1 shall not require implements during the test.

5.2.1.2 Light industrial tractors as defined in paragraph 3.2 shall be tested with items of integral equipment that are normally sold with the vehicle in those instances where the protective frame is expected to provide protection for the operator with such equipment installed.

F = not less than 0 in. and not more than 12 in. (305 mm), measured at center line front of back rest to center crossbar as shown in Fig. 4

G = 24 in. (610 mm) minimum horizontal distance between uprights throughout vertical distance defined by E

5.3 Static Test Procedure (optional to paragraph 5.4)

5.3.1 Test Conditions

5.3.1.1 The laboratory mounting base shall be the tractor rear frame and axle carrier or equivalent of the tractor utilized per paragraph 5.2.1 without wheels and rigidly mounted to support the protective frame being tested.

5.3.1.2 The protective frame and mounting connections shall be instrumented with the necessary recording equipment to obtain the required load-deflection data to be used in paragraph 5.3.3.6.

NOTE: The gages shall be placed on mounting connections before installation load is applied.

5.3.2 Definition of Terms

E_i = energy input, either side or rear, as noted

E_{is} = energy input to be absorbed during side overturn, ft-lb (E'_{is} in mkg)

E_{ir} = energy input to be absorbed during rear upset, ft-lb (E'_{ir} in mkg)

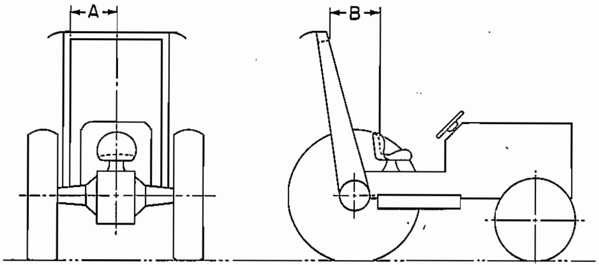


FIG. 1—TYPICAL FRAME CONFIGURATION

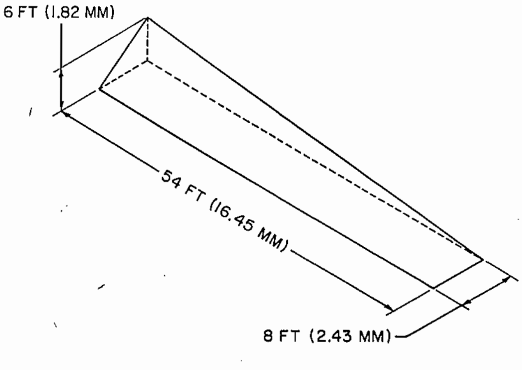


FIG. 2—RAMP

E_{is} = 723 + 0.4 W (E'_{is} = 100 + 0.12 W′)
E_{ir} = 0.47 W (E'_{ir} = 0.14 W′)
W = tractor weight as defined in paragraph 5.2.1, lb (W'_{ir}, kg)
NOTE: Velocity used for E_{1s} = 12 mph (19 km/hr).
A = measurement from centerline of seat to inside edge of upright member as shown in Fig. 1
B = measurement from front of seat back rest unloaded to front edge of crossbar as shown in Fig. 1
D_a = allowable deflection as defined in Figs. 3 and 4
L_s = static load, lb (kg)
D_s = deflection under L_s, in. (mm)
P_b = maximum observed force in mounting connection under static load, L_s, lb (kg)
P_u = ultimate force capacity of mounting connection, lb (kg)
FSB = design margin for mounting connection

$$\mathrm{FSB} = \frac{P_u}{P_b} - 1$$

D_{su} = deflection at rupture under static load L_s, in. (mm)
$L_s - D_s$ = static load-deflection diagram
E_u = ultimate energy that can be absorbed by the frame, ft-lb (mkg). (Maximum area under modified $L_s - D_s$ curve from 0 to point of frame rupture)
FER = factor of energy ratio

$$\mathrm{FER} = E_u/E_{ir}; \quad \text{also} = E_u/E_{is}$$

D_m = deflection maximum, under E_i, in. (mm)
$L_s - D_s$ diagram (modified)—to account for increase in strength due to increase in strain rate. Raise L_s in plastic range, $L_s \times K$
K = increase in yield strength induced by higher rate of loading (1.3 for hot rolled low carbon steel SAE 1010–1030). Low carbon is preferable; however, if higher carbon or other material is used, K must be determined in the laboratory

5.3.3 Test Procedure

5.3.3.1 Apply L_s to destruction in side load (Fig. 3), record L_s, D_s, and S_b simultaneously.

5.3.3.2 Using data obtained in paragraph 5.3.3.1, construct the L_s—D_s diagram as shown typically in Fig. 5.

5.3.3.3 Construct the modified L_s—D_s diagram as per paragraph 5.3.2 and as shown in Fig. 6. Determine E_u.

5.3.3.4 Calculate E_{1s}. Determine D_m as the abscissa at which the area under the modified $L_s - D_s$ diagram = E_{1s}.

5.3.3.5 Calculate FER.

5.3.3.6 Calculate FSB.

5.3.3.7 Repeat test utilizing L_r (rear input, see Fig. 4) and utilize E_{1r}.

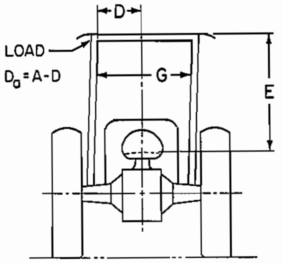


FIG. 3—STATIC SIDE LOAD OR SIDE OVERTURN TEST

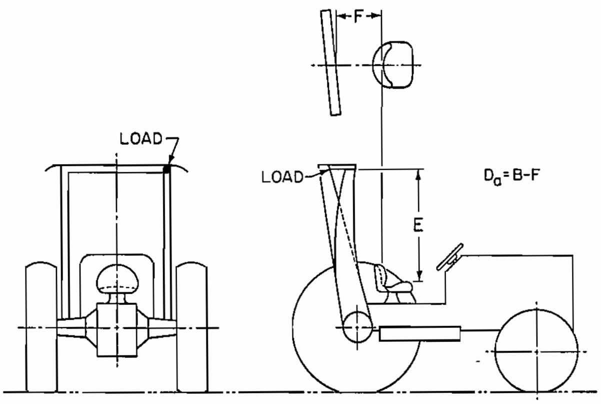


FIG. 4—STATIC REAR LOAD OR REAR OVERTURN TEST

5.3.4 Static Test Performance Requirements

5.3.4.1 Design factors shall be incorporated in each design to withstand overturn test in paragraph 5.2. These factors will be generally met if the following conditions are adhered to in both side and rear loading.

5.3.4.2 $D_m < 0.9\ D_a$.

5.3.4.3 FER < 1.5.

5.3.4.4 FSB ≧ K − 1.

5.4 Dynamic Test Procedure (optional to paragraph 5.3)

5.4.1 Test Conditions

5.4.1.1 The protective frame and tractor shall comply with paragraph 5.2.1.

5.4.1.2 The dynamic loading shall be produced by the use of 4410 lb (2000 kg) weight acting as a pendulum. The impact face of the weight shall be 27 ± 1 in. by 27 ± 1 in. (686 ± 25 mm by 686 ± 25 mm) and shall be constructed so that its center of gravity is within 1 in. (25.4 mm) of its geometric center. The weight shall be suspended from a pivot point 18-22 ft (5.49-6.71 mm) above the point of impact on the frame and shall be conveniently and safely adjustable for height. (See Fig. 7.)

5.4.1.3 For each phase of testing the tractor shall be restrained

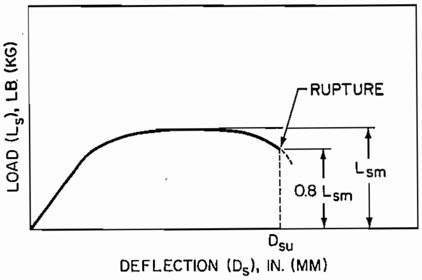


FIG. 5—TYPICAL $L_s - D_s$ DIAGRAM

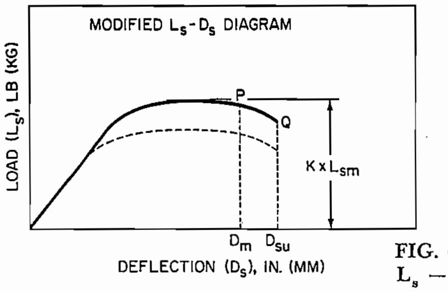


FIG. 6—TYPICAL MODIFIED $L_s - D_s$ DIAGRAM

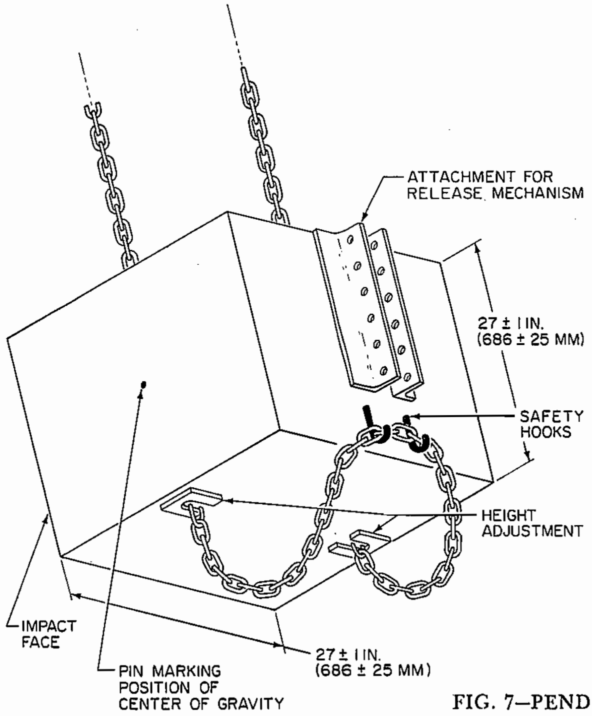


FIG. 7—PENDULUM

from moving when the dynamic load is applied. The restraining members shall be of 0.5-0.63 in. (12.5-16 mm) steel cable and points of attaching restraining members shall be located an appropriate distance behind the rear axle and in front of the front axle to provide a 15-30 deg angle between a restraining cable and the horizontal. The restraining member shall either be in the plane in which the center of gravity of the pendulum will swing or more than one restraining cable shall give a resultant force in this plane. (See Figs. 8 and 9.)

5.4.1.4 The wheel tread setting shall comply with paragraph 5.2.1.5. The tires shall have no liquid ballast and shall be inflated to the maximum pressure recommended by the tire manufacturer. With specified tire inflation the restraining cables shall be tightened to provide tire deflection of 6-8% of nominal tire section width. After the vehicle is properly restrained, a wooden beam 6 × 6 in. (15 × 15 cm) shall be driven tightly against the appropriate wheels and clamped. For the test to the side, an additional wooden beam shall be placed as a prop against the wheel nearest the operator's station and shall be secured to the floor so it is held tightly against the wheel rim during impact. The length of this beam shall be chosen so that when it is positioned against the wheel rim it is at an angle of 25-40 deg to the horizontal. It shall have a length 20-25 times its depth and a width 2-3 times its depth. (See Fig. 9.)

5.4.1.5 Means shall be provided for indicating the maximum instantaneous deflection along the line of impact. A simple friction device is illustrated in Fig. 10.

5.4.1.6 No repair or adjustments may be made during the test.

5.4.1.7 If any cables, props, or blocking shift or break during the test, the test shall be repeated.

5.4.2 Definition of Terms

W = tractor weight as defined in paragraph 5.2.1, lb (W′ in kg)

H = vertical height of lift of 4410 lb (2000 kg) weight, in. (H′ in mm). The weight shall be pulled back so that the height of its center of gravity above the point of impact is defined as follows:

$$H = 4.92 + 0.00267\,W;\ (H' = 125 + 0.150\,W')\ \text{(See Fig. 11.)}$$

5.4.3 Test Procedure

5.4.3.1 The frame shall be evaluated by imposing dynamic loading to rear and side of the structure, respectively. The pendulum dropped from the height determined in paragraph 5.4.2 imposes the dynamic load. The position of the pendulum shall be so selected that the initial point of impact on the frame shall be in line with the arc of travel of the center of gravity of the pendulum. A quick release mechanism should be used but shall not influence the attitude of the block.

5.4.3.2 Impact at Rear—The tractor shall be properly restrained per paragraphs 5.4.1.3 and 5.4.1.4. The tractor shall be positioned with respect to the pivot point of the pendulum such that the pendulum is 20 deg from the vertical prior to impact as shown in Fig. 8. The point of impact shall be that part of the frame likely to hit the ground first in a rearward overturning accident. If the configuration of the frame is such that the impact with the ground might be taken by one corner or by a fixed protruding member, this location shall receive the pendulum blow during the test.

5.4.3.3 Impact at Side—The blocking and restraining shall conform to paragraphs 5.4.1.3 and 5.4.1.4. The point of impact shall be that part of the protective frame likely to hit the ground first in a sideways accidental upset. The side impact shall be applied to the side opposite that used for rear impact.

5.4.4 Dynamic Test Performance Requirements—Design factors shall be incorporated in each design to withstand overturn test in paragraph 5.2. These factors will be generally met if the conditions in paragraph 5.2.3 are adhered to in both side and rear loading.

5.5 Protective Frame Test Performance Requirement

5.5.1 Compliance as specified in paragraph 5.2.3.

5.5.2 Compliance as specified in paragraph 5.3.4 or 5.4.4.

5.5.3 The overhead weather shield, fenders, or other parts in the operator area may be deformed but shall not shatter or leave sharp edges exposed to the operator, or violate the dimensions as specified in paragraph 5.2.3.3.

5.5.4 No battery liquid, fuel, or lubricant spillage occurs in the operator area that might be harmful to the operator in the event of an upset.

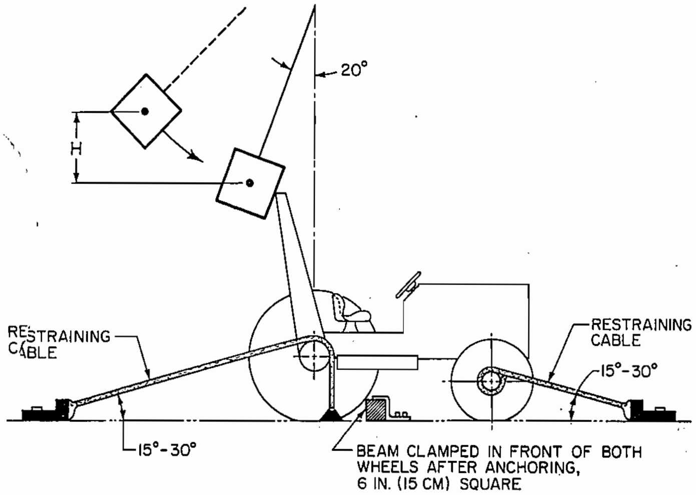

20°
H
RESTRAINING CABLE
RESTRAINING CABLE
15°-30°
15°-30°
BEAM CLAMPED IN FRONT OF BOTH WHEELS AFTER ANCHORING, 6 IN. (15 CM) SQUARE

FIG. 8—METHOD OF IMPACT FROM REAR

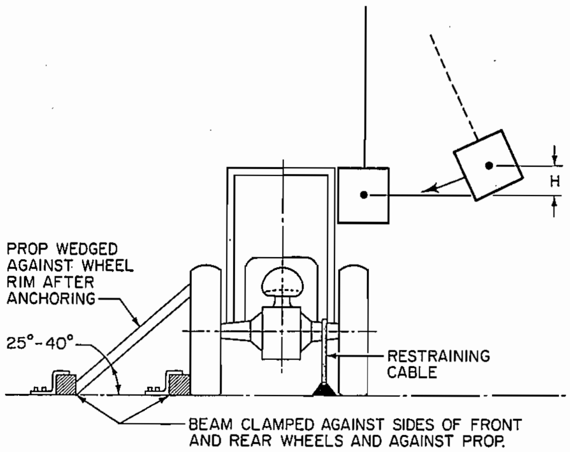

H
PROP WEDGED AGAINST WHEEL RIM AFTER ANCHORING
25°-40°
RESTRAINING CABLE
BEAM CLAMPED AGAINST SIDES OF FRONT AND REAR WHEELS AND AGAINST PROP.

FIG. 9—METHOD OF IMPACT FROM SIDE

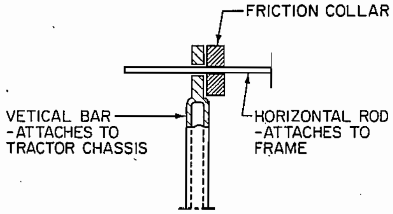
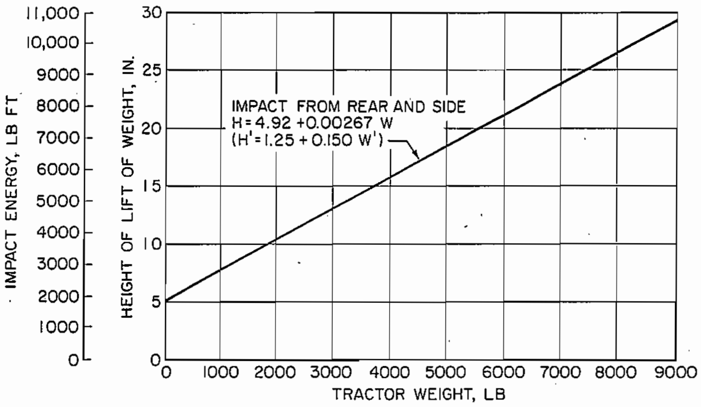

FRICTION COLLAR
VETICAL BAR -ATTACHES TO TRACTOR CHASSIS
HORIZONTAL ROD -ATTACHES TO FRAME

FIG. 10—METHOD OF MEASURING INSTANTANEOUS DEFLECTION



NOTATION OF FORMULAE
H = HEIGHT OF LIFT OF WEIGHT IN IN. (H′ IN MM)
W = UNBALLASTED WEIGHT OF TRACTOR IN LB (W′ IN KG)

FIG. 11—IMPACT ENERGY AND CORRESPONDING LIFT HEIGHT OF 4410 LB (2000 KG) WEIGHT